Dual voting axial position measurements

a must for sound protection and management practices

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A good machinery management system helps a company protect and manage its machinery. Protection implies automated shutdown without human intervention. Management refers to decisions and actions made by humans using information available from machinery information systems. When considering axial (thrust) position measurements, it is important to understand that turbomachinery cannot be adequately protected or managed using a single axial probe. To achieve the goals of protection and management, the American Petroleum Institute (API) and others recommend the use of two axial probes to measure axial rotor motion.

Machinery Protection

When considering any monitoring parameter used to automatically shut down a machine train, it is important to evaluate the ability of the transducer and monitor system to produce a reliable signal. The system must be able to provide that signal without fail, even if the machine is experiencing severe distress. It is equally important that the system does not cause a false shutdown due to misapplication or improper installation techniques.

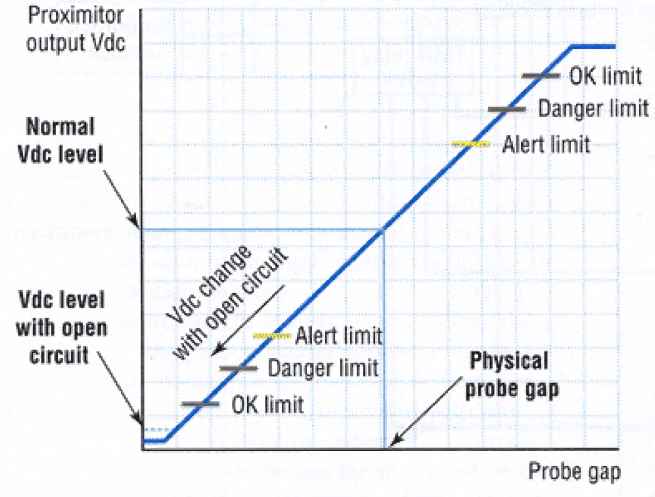

Figure 1. 3300 Proximity Transducer System response to an open circuit probe condition.

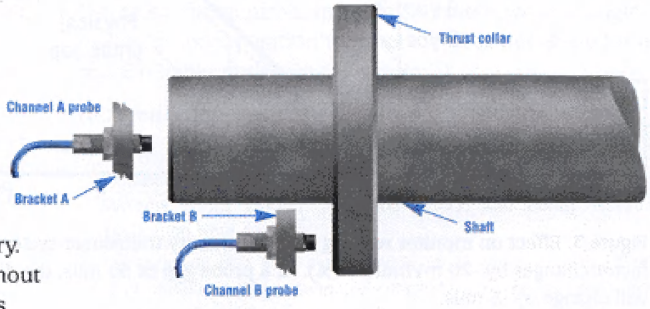

Figure 2. Axial position probes mounted on separate brackets, observing a shaft with non-integral thrust collar.

In order for an axial position measurement system to provide reliable shutdown capability, it is essential to have a minimum of two axial position probes. The system must also vote on the two probe inputs before it will initiate a shutdown; that is, both probe signals must indicate a danger condition (dual voting, AND logic).

While a single axial probe can provide an accurate indication of distress conditions, there are cases where a single probe will provide a false danger indication which might improperly shut down the machine.

If a single probe experiences a short circuit or an open circuit condition, the monitor will detect an alert and danger signal before it reaches a NOT OK limit (Figure 1). The monitor has time delays associated with the danger circuitry, and will enable the Danger Defeat circuitry (after detecting a NOT OK condition) before the danger contact closure is initiated. When there are very short, danger time-delays on axial position monitors, slight changes in circuit components or a sticking relay could cause a false shutdown. These short time-delays are used when there is a potential for rapid, highly destructive events caused by relatively small changes in axial position.

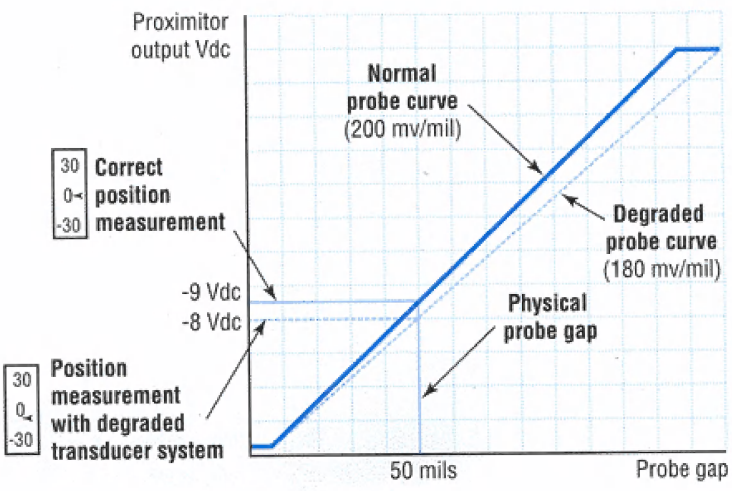

Figure 3. Effect on monitor reading when proximity transducer system scale factor changes by -20 mV/mil (-10%). At a probe gap of 50 mils, the display will change by -5 mils.

When two probes are installed properly, it is extremely unlikely they will be affected by the same problem in a way that will result in simultaneous danger levels and a shutdown. Proper installation (Figure 2) includes mounting the probes on separate brackets so a loose bracket won't affect both probes. It also means routing the cables from each probe in separate conduits, at least as far as the Proximitor® sensor housing, to minimize the potential of both cables being damaged by something as simple as the conduit being used as the rung of a ladder. If handled properly, the dual voting, axial probe installation will nearly eliminate the possibility of a false shutdown due to short, open, or intermittent conditions.

Machinery Management

When axial position measurements do not initiate automatic shutdown, the Operators are responsible for making decisions and managing machinery based on the information they receive from the measurement system. When making those decisions, the Operators (or Maintenance or Machinery personnel) must have a measurement that will allow them to accurately assess what is happening inside the machine. The Operators cannot confidently make that assessment with the information from a single probe.

If a single axial position monitor indicates a shift in axial position, one of three things may have occurred: a true mechanical change in rotor position has occurred, the performance of the monitor or transducer system has deteriorated, or the position of the probe or probe mounting bracket has changed. With a single probe, it is very difficult to decide which has occurred.

The change in performance of the monitoring system could be the result of moisture ingression or some other intrusive mechanism at the probe tip. It could also be due to degradation of Proximitor sensor compo-

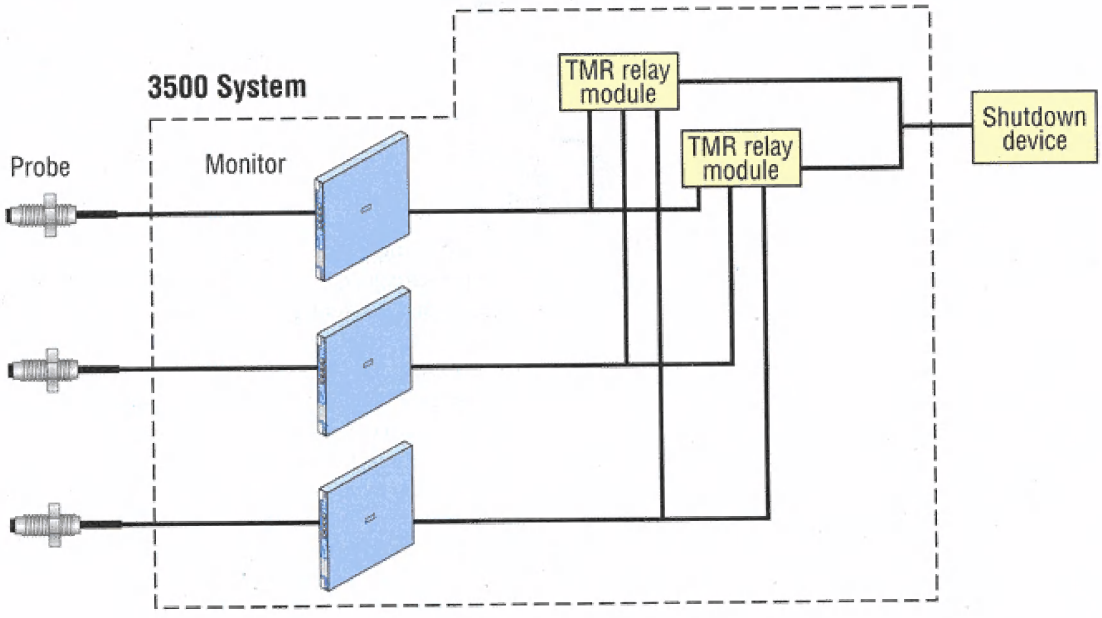

Figure 4. 3500 Monitoring System showing Triple Modular Redundant (TMR) configuration.

nents. In either case, the result will be a change in the scale factor of the transducer system. The change in scale factor will change the dc voltage output for the same physical gap between the probe and shaft (Figure 3). As a result, the axial position monitor will indicate a change in the axial location of the rotor when, in fact, the rotor position has not changed.

In addition, the transducer system could be operating properly, but the probe or probe mounting could be changing position (due to loosening or thermal effects). That condition would also indicate a change in rotor axial position on the monitor when there has been no change in rotor position.

The Operator is then left with three distinctly different causes for a change in the axial position indication: (1) a real movement of the rotor, (2) a faulty monitor or transducer system, or (3) a movement of the probe mounting bracket. With a single probe, one way to check is to remove the entire transducer system, plot the system linearity curve, and compare it to the known baseline curve that was documented when the transducer system was initially installed (if it was done and if it can be found). Many times axial probes are internally mounted, and removal of the axial probe is often virtually impossible while the machine is running. In addition, it is generally discouraged because it is impossible to reliably re-establish the original axial reference point for the probe once it has been removed.

With two axial position probes, it is far easier to determine what is actually happening in the machine. If both monitor channels show a position change, it is highly likely that there is real movement of the rotor. It is highly unlikely that both transducer systems would experience the same performance deterioration. If only one channel is indicating motion, the probe may be giving faulty information or additional insight to the malfunction mechanism.

Summary

Whether your goal is to protect or manage your machinery, it is important that you use a minimum of two probes to monitor the rotor axial position of your machinery. A single axial probe cannot protect a machine without introducing concerns about false shutdowns. In addition, the information from a single probe cannot be interpreted to identify, with certainty, the cause of all changes in the axial position indication. For those reasons, Bently Nevada encourages the use of dual voting axial position measurements with our 3300/20 and 3500/40 monitors, which fully comply with API-670 recommendations for axial position monitoring. It is important to note that our 3300 and 3500 axial position monitors are designed to take two probes as an input to the system. In addition, the 3500 System offers Triple Modular Redundant (TMR) capabilities for the very highest level of protection (Figure 4).

Finally, it is important to consider that people sometimes elect to use the system for automated shutdown once it is installed in the field, even though it was not in the original plans to do so. This is particularly true of axial position measurements where catastrophic problems can occur very quickly, without enough time for Operator intervention. Installing a system with a single probe for axial position monitoring does not allow for a more reliable option in the future.

References

1. For more details on proper installation practices, see API-670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems, Third Edition, November 1993, and Bently Nevada Application Note AN028.
2. The inclusion of a third axial position probe can provide the final piece of data needed to definitively diagnose a machinery or monitor system malfunction.

So Why Not Radial Vibration?

While redundant measurements are becoming more prevalent (including Triple Modular Redundant, TMR) for radial vibration, it is still not heavily encouraged for plant systems. There are three reasons:

1. The most common failures of the transducer systems and the wiring are short or open circuits. If that happens on axial position monitors, the monitor senses a condition which votes for shutdown. In contrast, the vibration monitor looks at the AC component of the electrical signal, and that component goes to zero when a short or an open circuit occurs. Thus, the monitor indicates zero vibration, and there is no danger of false shutdown.

2. Minor changes in scale factor have vastly different effects on vibration and position measurements. A scale factor change can result in significant changes in a position measurement. For example, a 10 mv/mil change in scale factor can result in as much as a 5 mil shift in the axial position indication. That same change in scale factor would only result in a 5% change to the radial vibration levels (or approximately 0.1 mil pp on a machine vibrating at 2.0 mils pp).

3. If a small change in vibration occurs, the skilled diagnostician immediately looks at the radial position and radial vibration measurements from adjacent vibration transducers. There is little opportunity to produce similar, correlated sets of data with axial position changes when there is only one axial probe.